Risk Analysis: Alternative Approaches

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TWWG

The WreathWood Group Background in Risk Assessment

- Risk and reliability modeling in nuclear submarine safety (UK, 1975); first owner-funded nuclear plant PRAs (US, 1979)
- PRA safety case (UK, 1978); Testimony on risk (US 1982)
- Developers of numerous PRA & HRA methods
- More than 20 PRA studies for nuclear, aerospace, chemical process & military facilities/platforms
- PRA & HRA expert advice/review to NRC, DOE, USA, NAS
- Evaluations of medical, chemical, aviation & maritime errors
- PRA & HRA Standards for ASME, ANS, IEEE

What Is a Risk Assessment?

- A set of event trees and fault trees
- A simulation model
- A human reliability analysis
- An integrated reliability – engineering physics differential equation model
- A RAC* code evaluation
- A qualitative description of hazards scenarios
- A standards review

* Risk Assessment Code - Consequence Category: I Catastrophic, to IV Negligible
Army/chemical industry - Frequency: A Frequent, B Probable, to F Rare, not credible

What Is a Risk Assessment?

$$< s_i, \ell_i, x_i >$$

Where

s_i = a scenario

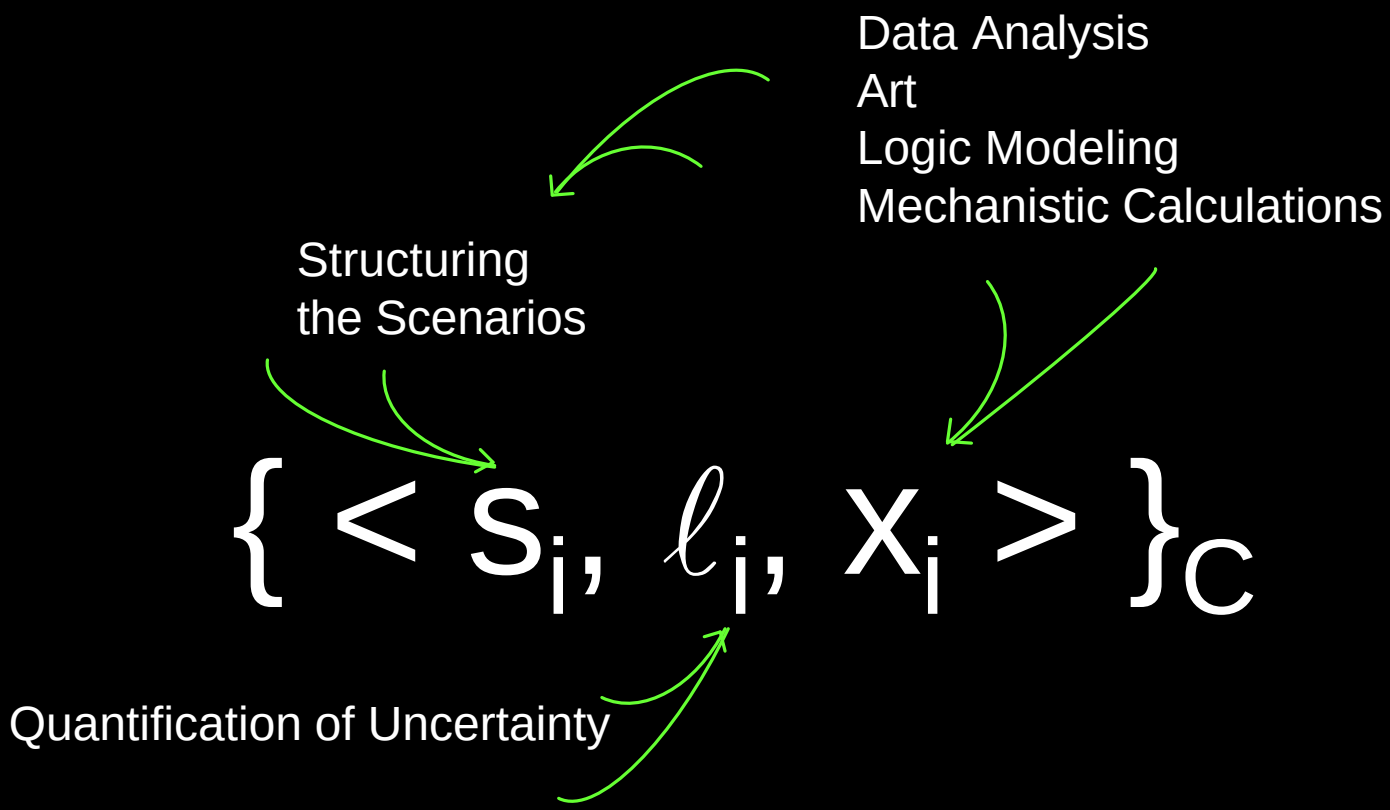
ℓ_i = its likelihood

x_i = its consequences

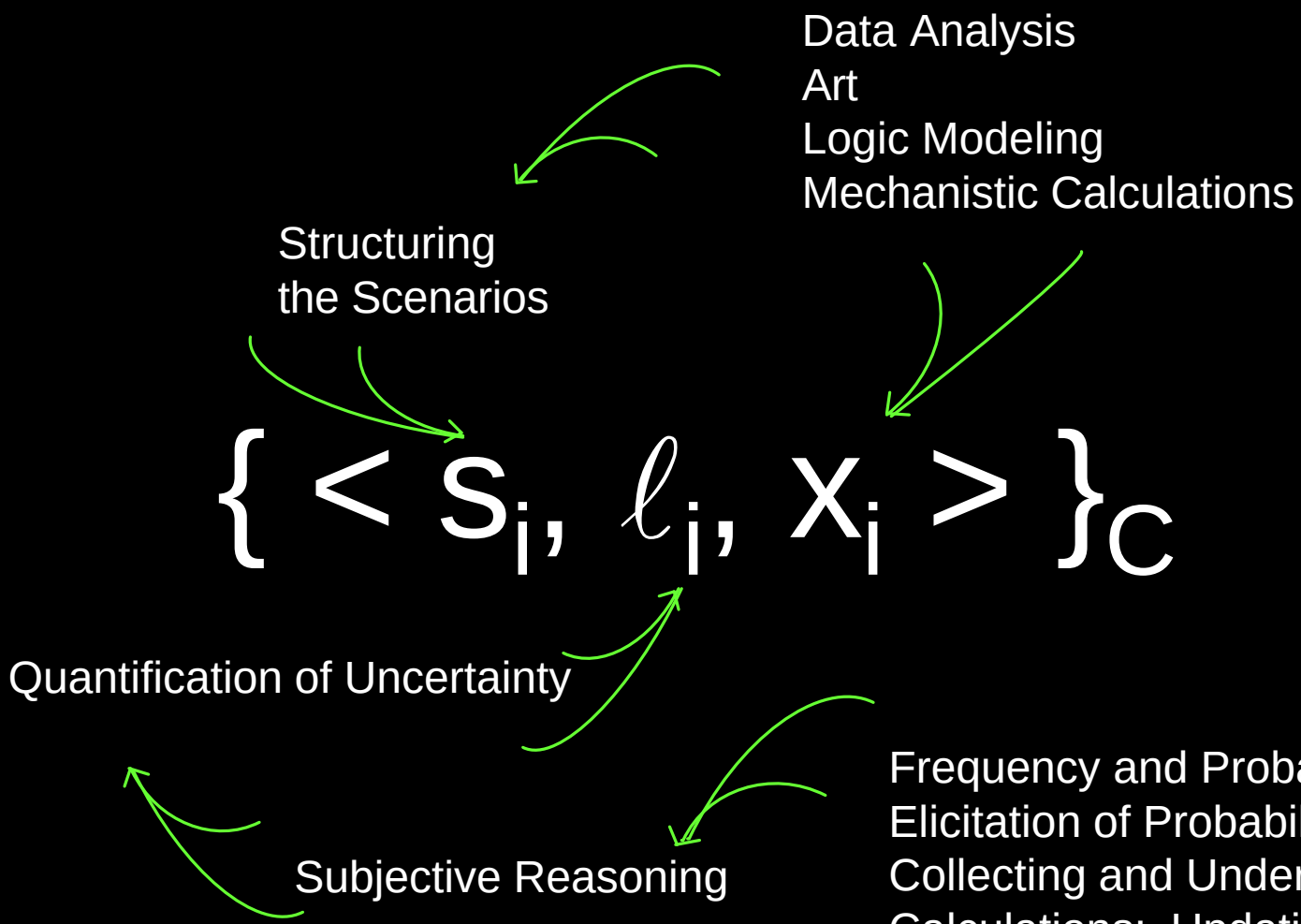
What Is a Risk Assessment?

$$\{ < s_i, \ell_i, x_i > \}_C$$

What is a Risk Assessment?



What is a Risk Assessment?



What Risk Assessment Tools Are Available?

Structuring the scenarios

- Event sequences
- Systems analysis
- Human reliability analysis

Parameter estimation

Consequence assessment

Almost all in one - Simulation

Risk Assessment Tools

Event sequence development/analysis

- Data analysis
- HAZOP*
- Qualitative scenario descriptions
- Event sequence diagrams
- Event trees (quantitative tools/different approaches)
- Simulation generated

* Hazard and Operability Study developed by chemical industry uses walkdown and “guide questions”

Risk Assessment Tools

Systems analysis including common cause

- Simulation (advantage for processes, time sequence and routine events, e.g.,“shadowing”)
- Fault tree analysis (advantage for rare events)
  - USNRC *Fault Tree Handbook*
- Reliability block diagrams (weak quantification tools)
- Go methodology (mimics P&ID)
- Mil Standard (oversimplified)
- Data Analysis

Risk Assessment Tools

Human reliability analysis

- Many methods because of complexity (simple hardware models do not work)
- All categories of unsafe acts and context
- Parameter estimation (e.g., component failure rates, unavailability, human error rate)
- Data analysis
  - Frequentist analysis and Bayesian analysis
  - USNRC *Probabilistic Risk Assessment Data Handbook* (soon)
- Expert elicitation (e.g., Volpe CBTM human factors analysis)

Risk Assessment Tools

Overall analysis

- Qualitative comparison
  - Paired comparison
  - Salient feature comparison, etc.
- Standards comparison
  - RAC scores (semi-quantitative frequency/consequence)
- Quantitative comparison (on issues of relevance)
  - Event tree/fault tree (rare events)
  - General purpose simulation (processes)
  - Specialized simulation (improved rare event results)
  - Data Analysis (accident rate, etc.)
  - Combined approaches